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J R Yabsley

JONNE YABSLEY
TEAM LEADER EXAMINATION
SUPPORT AND SALES

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PROVISIONAL SPECIFICATION

Invention Title:

Feedthrough for electrical connectors

The invention is described in the following statement:

Field of the Invention

The present invention relates to a method of forming miniature connector systems for electrical products. More specifically, the present invention relates to a method of forming hermetically sealed but electrically conducting feedthroughs for devices, including biosensors, and implantable devices. Examples of implantable devices include the implantable component of a cochlear implant hearing prosthesis. An electrically conducting feedthrough formed using the method is also described.

Background of the Invention

The term 'feedthrough' as used herein refers to the provision of an electrically conducting path extending from the interior of a hermetically sealed container or housing to an external location outside the container or housing. Typically, a conductive path is provided through the feedthrough by an electrically conductive pin, which is electrically insulated from the container or housing by an electrically insulating body surrounding the pin.

A feedthrough device therefore allows one or more electrical connections to be made with electronic circuitry or components within the hermetically sealed container or housing, whilst protecting the circuitry or components from any damage or malfunction that may result from exposure to the surrounding environment.

There are many applications that require feedthrough devices to provide an electrically conducting path whilst also sealing the electrical container or housing from its ambient environment. Historically, the first such devices were widely used in vacuum technology allowing for the transfer of signals between chambers of differing pressures. In such applications, the vacuum tubes had to be sealed because they could only operate under low-pressure conditions.

Over time, and with the advent of electrical devices capable of being implanted in body tissue to provide therapy to a patient, such as cardiac pacemakers, defibrillators and cochlear implants, the need to provide feedthrough devices with improved hermeticity has become increasingly

important. As the environment of living tissue and body fluids is quite corrosive and the implants may contain materials which may be detrimental to the patient, a hermetic feedthrough device is used to provide a barrier between the electronic components of the device and the external corrosive environment of the human body. With implantable medical devices in particular, it is critically important that the hermetic seal of the device be physically rugged and long lasting. For this reason, stringent requirements are imposed on the hermeticity of an implanted device, typically requiring a seal that provides a leakage rate of less than 10^{-8} cc/sec.

In this regard, in medical implant applications such as those used in pacemaker devices and cochlear implants, the feedthroughs typically consist of a ceramic or glass bead that is bonded chemically at its perimeter through brazing or the use of oxides, and/or mechanically bonded through compression, to the walls of the sealed package. A suitable wire or other conductor passes through the centre of the bead, and this wire or conductor must also be sealed to the bead through chemical bonds and or mechanical compression. In this regard, the feedthrough is typically cylindrical and the wire(s) or conductor(s) mounted within the bead are centred or mounted in a uniform pattern, centrally within the bead.

Other materials and processes are known for making feedthroughs, for example, from aluminium oxide ceramic and binders. These types of feedthroughs are widely used for cardiac and cochlear implants. One of the processes for making such a feedthrough consists of pre-drilling holes in a sintered ceramic plate and then forcing electrical conductive pins through the holes. However, this method does not necessarily guarantee a hermetic seal, resulting in unsatisfactory leakage rates. A second method involves inserting the conductive pins into an unsintered (or 'green') ceramic plate and then curing the assembly by firing to achieve a hermetic seal. A major disadvantage of this last method is that, historically the manufacturing process has been performed by hand. Such a method of manufacture can lead to inaccuracies and be time consuming, expensive and labour intensive. Moreover, the feedthrough devices resulting from such a process do not necessarily have precisely positioned electrical conductors, with the position of the conductors being greatly dependent upon the process itself. Further, as the conductors

are typically wires being of a general cylindrical shape and configuration, the size and shape of the conductor extending from the insulative material of the feedthrough is generally the same as the conductor embedded in the insulative material of the feedthrough. This aspect has made it difficult to design feedthrough devices wherein the shape of the conductor element differs over the length of the conductor such that the external ends of the conductors are maximised to suit the specific purpose of the feedthrough device.

As implantable devices continue to develop and become thinner and smaller and more electronically sophisticated, the requirements of the feedthrough have also increased. In cochlear implants in particular, where there are now typically 22-24 electrode leads, there is a need for 22-24 conductive pins passing through the feedthrough device. As the desire for more electrodes and smaller feedthroughs increases, the demands placed upon the design of the traditional feedthrough also increases. The problems in fabricating such a feedthrough device on such a large scale are therefore quite significant, especially when one considers the relatively high degree of labour intensity and specialisation of the current fabricating methods.

While the above described prior art feedthrough devices and fabrication methods have proven successful, it is a relatively slow and labour intensive process to manufacture such devices. The method of manufacture of the feedthrough also presents limitations in the number of conductors that can pass through the feedthrough and the position and configuration of such conductors within the feedthrough device, particularly in applications where this number needs to be maximised.

The present invention is directed to a new method of forming such a feedthrough that addresses at least some of the problems with prior art processes.

The present invention also potentially allows more flexibility in the design of feedthrough devices by providing control over the position and configuration of the conductors through the device, the physical shape and size of the device, the number of conductors used and the overall hermeticity of the feedthrough device.

Any discussion of documents, acts, materials, devices, articles or the like which has been included in the present specification is solely for the purpose of providing a context for the present invention. It is not to be taken as an admission that any or all of these matters form part of the prior art base or were common general knowledge in the field relevant to the present invention as it existed before the priority date of each claim of this application.

Summary of the Invention

Throughout this specification the word "comprise", or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated element, integer or step, or group of elements, integers or steps, but not the exclusion of any other element, integer or step, or group of elements, integers or steps.

According to a first aspect, the present invention is a method of forming an electrically conducting feedthrough comprising the steps of:

(i) forming an electrically conductive structure comprising a sacrificial component and non-sacrificial component;

(ii) coating a relatively electrically insulating material on to at least a portion of the non-sacrificial component; and

(iii) removing at least a portion of the sacrificial component.

The electrically insulative material is preferably a ceramic material or hermetic glass material, suitable for use in a feedthrough application.

In one embodiment, the insulative material can be coated on the non-sacrificial component and not coated or moulded on to at least a portion of the sacrificial component of the conductive structure. Still further, step (iii) can comprise removing at least that portion of the sacrificial component on to which the insulative material has not been coated.

In one embodiment, the electrically conductive structure can be formed from a film or shim of an electrically conductive metal or metal alloy. In a preferred embodiment, the film or shim is formed from a biocompatible metal or

metal alloy. In one such embodiment, the electrically conductive structure can be formed from a film or shim of platinum.

In this embodiment, the film or shim of platinum can be formed into a shape comprising the sacrificial component and the non-sacrificial component of the electrically conductive structure. In this embodiment, it will be appreciated that that portion of the film or shim comprising the non-sacrificial component may comprise more than one portion of the film or shim. Similarly, that portion of the film or shim comprising the sacrificial component may comprise more than one portion of the film or shim.

In one embodiment, the electrically conductive component may comprise a film or shim having a shape comprising two or more separated substantially elongate members extending between respective transverse support members. In a further embodiment, the film or shim can have at least ten separated substantially elongate members extending between the respective support members. In a preferred embodiment, the support members are substantially parallel with respect to each other. More preferably, the support members are straight and are in a parallel arrangement.

The separation of the substantially elongate members is preferably such that the insulative material can be coated between the members and so prevent electrical conduction between the respective elongate members at completion of the method according to the first aspect.

In a preferred embodiment, the shape of the electrically conductive component can be formed in step (i) by punching the shape, using a suitable shaped and dimensioned punching tool, from a film of platinum. In another embodiment, the shape of the electrically conductive component can be formed in step (i) by using electrical discharge machining (EDM), which is also known as spark erosion, to remove unwanted portions of the sheet. In a preferred embodiment, the EDM equipment used in the process has a cutting tool comprising an electrode. The cutting tool does not physically cut the sheet but instead relies on the equipment generating a series of electrical discharges between the electrode and the sheet in a dielectric fluid. The electrical discharges serve to vaporise the sheet in the region adjacent the cutting tool.

In a preferred embodiment, the cutting tool has a size and shape that matches the size and shape of the portion of the sheet to be removed from the sheet during the machining steps. In this embodiment, it is preferred that the tool is brought adjacent the sheet at a number of different locations so as to remove differing portions of the sheet. This multiple use of the tool preferably serves to gradually build up the pattern of the electrically conductive component.

In a preferred embodiment, the cutting tool can be used to form a series of discrete linear conductive members from a sheet of platinum or other suitable metal. The linear conductive members are preferably aligned in a parallel arrangement.

In another embodiment, the cutting tool can be used to form a series of discrete linear conductive members from a plurality of sheets of platinum or other suitable material stacked one atop the other. In this manner, a large number of electrically conductive components can be prepared with a single cutting motion of the cutting tool. In such an embodiment, a method known as "wire cutting" can be employed. This method operates in a similar manner to EDM/spark erosion methods wherein a wire is passed through a stack of sheets or foils of conductive material with this wire becoming the electrode causing the erosion of material adjacent the electrode. By using this method a plurality of foils can be patterned simultaneously, resulting in a process that is capable of mass producing patterned conductive foils to be used to create the feedthrough device of the present invention.

In this embodiment, at least a portion of each of the substantially elongate members extending between the support members are coated with the insulative material (ie. step (ii) described in more detail below). As mentioned, the insulative material can be alumina but other suitable ceramic types can be envisaged.

In another embodiment, the step of forming the electrically conductive structure can comprise the steps of:

(a) forming a relatively electrically insulative disc having an outer periphery defining a plurality of outwardly extending teeth having notches therebetween; and

(b) winding an electrically conductive element around the disc such that at least some of the notches have a portion of the conductive element passing therethrough.

In this embodiment, the insulative disc can be formed of the same ceramic material as that used in step (ii) of the method described above. In another embodiment, a different ceramic can be used. The insulative disc can have a plurality of equally spaced notches and teeth about its outer periphery.

In this embodiment, each of the notches can receive a conductive element. Preferably, a single metal wire is used for each disc. The wire preferably comprises platinum wire. The wire can have a diameter of about 25μm.

Once the conductive element has been passed through each of the notches, the insulative disc and surrounding conductive element can be overmoulded with a coating of insulative material as defined in step (ii) of the method described above.

In a still further embodiment, the step of forming the electrically conductive structure comprises a step of forming a sheet of platinum having a plurality of integrally attached substantially elongate members extending outwardly from at least a portion of the periphery thereof. In a preferred embodiment, the elongate members extend outwardly and in a direction out of the plane of the sheet. For example, the elongate members can extend outwardly and upwardly from the sheet. In this embodiment, the elongate members can be rectangular in shape.

In this embodiment, the sheet can be rectangular or square. In this embodiment, at least three sides of the sheet can have elongate members extending at least out of the plane of the sheet.

In a still further embodiment, the step of forming the electrically conductive structure comprises a step of spirally coiling an electrically conductive wire, such as platinum wire, along at least a portion of a length of a screw thread. Once positioned, an insulative layer can be moulded around the thread and the wire. Once the insulative layer has cured, the screw thread can be withdrawn from the insulative material so leaving the coiled wire embedded within the inner surface of the insulative layer.

The step of coating the electrically conductive structure preferably comprises a step of mounting or clamping the conductive structure in a mould and then moulding a coating of the insulative material on and/or around the conductive structure.

Where the conductive structure comprises a plurality of substantially elongate members formed from a film or shim of platinum, the insulative material is preferably coated or moulded around at least a portion of the substantially elongate members of the conductive structure. In this embodiment, said portion of the substantially elongate members comprises a portion of the non-sacrificial component of the electrically conductive structure. While this embodiment envisages the film or shim being shaped as desired prior to clamping or mounting in the mould, it will be appreciated that a film of platinum could be firstly mounted or clamped in the mould and then shaped or punched as required prior to the moulding or coating step.

Where the conductive structure comprises an insulative disc having a notched outer surface and a conductive element passing through the notches around the disc, the insulative material is preferably moulded around the disc such that at least those portions of the conductive element passing through the notches of the disc outer surface are encapsulated in the insulative material.

Where the conductive structure comprises a sheet having a plurality of substantially elongate members extending at least out of the plane of the sheet, the insulative material is preferably moulded to both sides of the sheet and elongate members, thereby encapsulating at least a portion of the members in the insulative material.

Where the conductive structure comprises a coiled wire embedded within the inner surface of an insulative layer, the orifice left by the withdrawal of the screw thread can be filled with insulative material.

In a preferred embodiment, the mould can comprise an injection mould. In one embodiment. step (ii) of the method can comprise a step of using powder injection moulding (PIM) to mould the insulative material around the desired portion of the conductive structure.

In this moulding process, insulative material such as fine ceramic powder is mixed with a carrier chemical, typically called binder, and homogenised to create a feedstock for the injection mould. The presence of the binder serves to make the feedstock sufficiently fluid to be used in an injection moulding process. Once moulded, the insulative material can be allowed to at least partially set. The resulting moulded part is hereinafter called the green body.

Once the green body is formed, the sacrificial component of the electrically conductive structure can be removed. During this step, it is possible that a portion of the green body may also need to be removed. In one embodiment, the sacrificial component can be removed by being cut, abraded or ground away. In this regard, physical cutting with a knife, or laser cutting techniques, are envisaged.

Where the electrically conductive structure comprises the plurality of substantially elongate members extending between the transverse members, the sacrificial component preferably includes at least the transverse members so leaving a plurality of electrically insulated elongate members extending through the green body.

Where the electrically conductive structure comprises an insulative disc having a conductive element, such as a wire, passing through a plurality of notches, the sacrificial component can comprise that part of the conductive element not passing through the notches. On removal of the remainder of the conductive element, one is left with an insulative member having a conductive member passing therethrough at each location where a notch existed in the outer surface of the original insulative disc.

Where the electrically conductive structure comprises a sheet having a plurality of substantially elongate members extending at least out of the plane of the sheet, the sacrificial component preferably comprises the sheet from which each of the elongate members extend. With the sheet and substantially elongate members supported on one side by an insulative layer, the sheet can be punched from the structure leaving a ring of insulative material with the now separated elongate conductive members supported thereon. Another layer of insulative material can then be moulded between and around the ring thereby forming an insulative member having the elongate members extending therethrough from one face to the other.

Where the electrically conductive structure comprises a coiled wire embedded within an insulative coating, the sacrificial component preferably comprises adjacent portions of respective turns of the coiled wire.

In a still further embodiment, the method can comprise an additional step of debinding the green body. In this step, any binder in the green body is preferably extracted from the insulative material. In one embodiment, this step can comprise a chemical debinding in which the green body is soaked in a suitable solvent. In another embodiment, this step can comprise exposing the green body to a relatively elevated temperature. This temperature is preferably sufficient to boil off the binder from the green body while not causing the green body to undergo sintering. In one embodiment, the temperature is between about 150°C and 200°C.

During the debinding step, the insulative material preferably shrinks in dimension. This debinded insulative material member is hereinafter called a brown body.

When ready, the brown body can undergo a sintering step. The sintering step preferably comprises exposing the brown body to a suitable elevated temperature. In one embodiment, the sintering step can comprise exposing the brown body to a sintering temperature of about 1700°C. During the sintering step, the insulative member undergoes further shrinkage and becomes relatively more robust. The shrinkage of the insulative member also serves to

form a hermetic seal at the interface between the embedded conductive members and the surrounding sintered insulative member.

Once complete, the insulative member with the conductive members extending therethrough can be brazed into an orifice in the wall of a unit adapted to receive the feedthrough. Electrical connection can then be made to each end of the respective conductive members as required to form respective electrical conductive paths through the insulative body of the feedthrough.

According to a further aspect, the present invention is a feedthrough formed using one of the methods described herein.

In yet a further aspect, the present invention is a feedthrough comprised of one or more relatively electrically conductive structures extending through and embedded within a relatively insulative body, wherein the one or more electrically conductive structures are formed from a film or shim of an electrically conductive metal.

In one embodiment, the electrically conductive structures have an overall elongate length of at least 7mm and, more preferably, about 7.8mm. In a further embodiment, the width of the conductive structures is preferably between about 1.5-2.5 mm. In a still further embodiment, the film or shim from which the conductive structures are formed preferably has a thickness of between about 40 and 70 microns, more preferably about 50 microns.

In one embodiment of this aspect, the electrically conductive structures can be formed using one of the methods according to the first aspect of the invention.

Still further, the hermeticity of the interface between each of the interfaces between the respective electrically conductive structures and the relative insulative body or the degree of permeation of fluid between the conductive structure and the insulative body is preferably defined by the following relationship:

$$H = f(L, 1/A, 1/t) \qquad (1)$$

where L is the length of the electrically conductive structure extending from a first face to a second face of the insulative body;

A is the cross-sectional area of the electrically conductive structure; and

t is the time that the interface is exposed to the fluid, including bodily fluids.

It will be appreciated that the cross-sectional area A is related to a measurement of the perimeter of the electrically conductive structure as measured at right angles to the longitudinal axis of the structure. That is, the smaller the size of the interface between the conductive insert and the insulative material, the greater the degree of hermeticity of the feedthrough.

In one embodiment, the feedthrough can be brazed into the wall of an electrical device, such as an implantable stimulator unit of a medical implant device. In a preferred embodiment, the feedthrough can be adapted to be used with a cochlear implant hearing prosthesis to provide electrical conduction between the circuitry within an implantable stimulator unit and the intracochlear or extracochlear electrodes and/or the implantable receiver coil.

Each feedthrough preferably has sufficient conductive members embedded therein to ensure there are sufficient connectors to suit the desired application. In a cochlear implant application, the feedthrough would have to have sufficient conductive members embedded therein to ensure that there are sufficient connectors for each of the electrode channels of the intracochlear electrode array, one or more extracochlear electrodes, and the inputs from the receiver coil.

The present invention provides a method of forming a feedthrough for an implantable component comprising a relatively electrically insulative member having a plurality of relatively electrically conductive members extending therethrough. The method ensures the electrically conductive members are hermetically encased within the ceramic in a way that allows electrical connection through the feedthrough while preventing transfer of bodily fluids from outside the component into the interior of the component, as well as

preventing the transfer of potentially dangerous materials from internal of the component to the surrounding tissue and body fluids.

The present invention also provides the capability of using smaller sized conductive components, having a smaller perimeter of the cross section, thereby providing increased hermeticity. It is therefore possible to utilise the present invention to create feedthrough devices that are of similar dimensions to prior art feedthrough devices but which have far superior hermeticity properties. Equally, the present invention can be utilised to create feedthrough devices which are of much smaller dimensions than existing feedthrough devices having similar and improved hermeticity than is currently the case.

The present invention also provides the ability to create a feedthrough device having a relatively denser array of conductive structures than prior art devices, as the conductive components can be spaced closer together than is achievable in traditional devices.

Brief Description of the Drawings

By way of example only, preferred embodiments of the invention are now described with reference to the accompanying drawings, in which:

Fig. 1 is a plan view of one embodiment of a electrically conductive structure for use in the method according to the present invention;

Fig. 2 is a perspective view of the conductive structure overmoulded with an insulative ceramic member;

Fig. 3 is a plan view of the feedthrough formed from the conductive structure of Fig. 1;

Fig. 4a is a perspective view of an insulative ceramic disc having a saw-tooth outer surface for use in the formation of another embodiment of a conductive structure according to the present invention;

Fig. 4b is a perspective view of the ceramic disc of Fig. 4a with a conductive platinum wire coiled around the disc;

Fig. 5 is a perspective view of the disc of Fig. 4b with an overmould of ceramic material around the outer surface of the disc;

Fig. 6 is a feedthrough formed from the conductive structure of Fig. 4a;

Fig. 7 is a perspective view of a platinum sheet with elongate members extending out of the plane thereof for use as a conductive structure in another embodiment of a method according to the present invention;

Figs. 8a and 8b are perspective views of the sheet of Fig. 7 with a layer of ceramic moulded thereto;

Fig. 9 is a perspective view of a feedthrough formed using the sheet of Fig. 7;

Figs. 10a-10e are perspective views of a still further embodiment for forming a feedthrough using the method according to the present invention;

Fig. 11 is a simplified flow chart of the steps of one embodiment of the method according to the present invention.

Figs 12a is a side view of a stack of platinum sheets about to be machined into an electrically conducting feedthrough according to the present invention;

Fig. 12b is a top view of a platinum sheet highlighting the region of platinum to be removed in the process depicted in Fig. 12a;

Fig. 12c is a top view of machined sheet of platinum formed using the process depicted in Fig. 12a; and

Figs 13a-d depict another possible technique for forming a feedthrough according to the present invention.

Preferred Mode of Carrying out the Invention

The steps of one embodiment of a method of forming an electrically conducting feedthrough according to the present invention are depicted in Fig. 10.

The method 10 comprises a first step 11 of forming an electrically conductive structure comprising a sacrificial component and non-sacrificial component. Different examples of such structures are depicted in Figs. 1, 4b, 7, and 10b.

The method further comprises a step 12 of coating or moulding a non-electrically conductive insulative member on to at least a portion of the non-sacrificial component and not on to at least a portion of the sacrificial component of the conductive structure.

Still further, the method comprises a step 13 of then removing at least that portion of the sacrificial component of the conductive structure on to which the insulative member has not been coated or moulded.

Following removal of the sacrificial component of the conductive structure, the green body of the insulator can undergo a step of debinding 14 prior to a step of sintering 15. Once sintered, the ceramic feedthrough with the conductive members extending therethrough is ready for appropriate mounting in the wall of an implantable stimulator unit of a cochlear implant hearing prosthesis or other appropriate device.

As depicted in Fig. 1, the electrically conductive structure formed in step 11 can be formed from a film or shim 21 of biocompatible platinum. Other suitable electrically conductive metals or metal alloys can be envisaged.

As depicted in Fig. 1, the film or shim 21 of platinum can be formed into a shape comprising the sacrificial component and the non-sacrificial component of the electrically conductive structure. In this embodiment, the electrically

conductive structure comprises a plurality of separated elongate members 22 extending between respective parallel transverse support members 23,24.

The separation of the elongate members 22 is such that the insulative material when moulded around the members 22 can also move between the members 22 and so prevent electrical conduction between the respective members 22 at completion of the method 10.

In the depicted embodiment, the shape of the electrically conductive structure 21 is formed by punching the shape, using a suitable shaped and dimensioned punching tool, from a film of platinum. It is envisaged that this shape could be created by a variety of material removal methods, such as electrical discharge machining (EDM), micro-knifing and/or laser cutting.

Figures 12a, 12b and 12c depict one method of forming the electrically conductive structure according to a preferred embodiment. In this embodiment a method referred to as wire cutting is utilised. This method employs the principles of EDM methods to remove the unwanted material, however, in this instance the spark is created between the work-piece 60 being machined, for example a stack of platinum films 62, and a continuously moving wire 64, with the components emersed in a dielectric medium (not shown).

Figure 12a is a side view of this method and shows a number of foils of conductive material 62 stacked together to form a work-piece 60, said conductive material preferably being platinum or iridium, with the foils preferably being clamped together and immersed into a dielectric medium. The wire 64 is then fitted through the work-piece 60 by creating an appropriate aperture through the work-piece 60. A series of electrical discharges are then generated between the wire 64 and the work-piece 60 in the dielectric medium, causing erosion of the films 62 to occur in a desired pattern. Typically, the wire 64 is drawn through the work-piece 60 in a continuous feeding motion, for example in a downward motion shown by arrow A, however, the position of the wire 64 with respect to the work-piece 60 remains stationary, while the work-piece 60 is moved in the desired directions to created the desired pattern.

As is shown in Figure 12b, the hashed regions 66 are removed from each of the foils of conductive material in the work-piece 60. This then leaves a conductive film as depicted in Figure 12c as the cross-hashed region 68, which is essentially the same as that shown and described with reference to Figure 1.

As depicted in Fig. 2, at least a portion of each of the elongate members 22 extending between the support members 23,24 are coated or overmoulded with an insulative material 25 described in more detail below.

In the depicted embodiment, the step of moulding the insulative material 25 around the electrically conductive structure (step 12) comprises a step of mounting or clamping the conductive structure in a mould and then moulding the insulative material on and/or around the conductive structure.

In a preferred embodiment, the mould can comprise an injection mould. In one embodiment. step 12 can comprise a step of using powder injection moulding (PIM) to mould the insulative material around the desired portion of the conductive structure. In a preferred embodiment of this moulding process, fine ceramic powder is mixed with a binder and homogenised to create a feedstock for the injection mould. The presence of the binder serves to make the feedstock sufficiently fluid to be used in an injection moulding process. Once moulded, the insulative ceramic can be allowed to at least partially set and form a green body.

Once the green body is formed, the sacrificial component of the electrically conductive structure can be removed. In the embodiment depicted in Figs. 1 to 3, the sacrificial component can be removed by laser cutting. Other suitable material removal techniques, such as cutting or abrading techniques are also envisaged.

In the embodiment depicted in Figs. 1 to 3, the sacrificial component comprises the transverse members 23,24. Once these are removed, a plurality of respectively electrically insulated elongate members 22 remain extending through the green body 25.

In the embodiment depicted in Figs. 4a and 4b, the step 12 of forming the electrically conductive structure comprises the steps of:

(a) forming an insulative disc 30 having an outer surface defining a plurality of teeth 31 having notches 32 therebetween; and

(b) winding a platinum metal wire 33 around the disc 30 such that at least some of the notches 32 have a wire passing therethrough (as is depicted in Fig. 4b).

In the depicted embodiment, the insulative disc can be formed of a ceramic material such as that used in step 12 described above. In another embodiment, a different material could be used that exhibits the desired insulative properties necessary. The insulative disc 30 preferably has a plurality of equally spaced notches and teeth about its outer periphery.

As depicted in Fig. 4b, each of the notches 32 receive a portion of the wire 33. In the depicted embodiment, the wire has a diameter of about 25μm.

Once the wire 33 has been passed through each of the notches 32, the insulative disc 30 and surrounding wire can be overmoulded in step 12 with an outer annular coating of a suitable insulative material such as a ceramic 35. This material is preferably moulded around the disc such that at least those portions of the wire 33 passing around the notches 32 of the disc outer surface are encapsulated in the material 35.

The sacrificial component of the structure depicted in Fig. 5 comprises that part of the wire not passing through the notches 32. On removal of the remainder of the wire, one is left with a insulative member 35 having a platinum conductive member 36 passing therethrough at each location where a notch 32 existed in the outer surface of the original insulative disc 30.

Another method of forming a different conductive structure is depicted in Figs. 7 to 9. In this arrangement, step 11 comprises forming a multi-sided sheet 40 of electrically conductive material, such as platinum, having a plurality of integrally attached elongate members 41 extending outwardly from at least three sides of the periphery thereof. The elongate members extend outwardly

and in a direction out of the plane of the sheet. In the depicted arrangement, the elongate members 41 extend outwardly and upwardly from the sheet.

In this embodiment, a coating of insulative material 42 is preferably firstly moulded to one side of the sheet 40 and elongate members 41.

In this embodiment, the sacrificial component preferably comprises the sheet 40 from which each of the elongate members 41 extend. With the sheet and elongate members supported on one side by a layer of insulative material 42, the sheet 40 can be removed from the structure leaving a ring of insulative material with the now separated elongate members 41 supported thereon. Another layer of insulative material 43 can then be moulded between and around the ring thereby forming an insulative member having the elongate members extending therethrough from one face to the other. The result is a plurality of respectively electrically insulated elongate members 41 embedded within a ceramic green body comprised of layers 42 and 43.

In another embodiment depicted in Figs. 10a-10e, the step of forming the electrically conductive structure can comprise a step of spirally coiling an electrically conductive wire 52, such as platinum wire, along at least a portion of a length of a thread of a screw 51. Once positioned, a layer of insulative material 53 can be moulded around the thread 51 and the wire 52. Once the insulative material 53 has cured, the screw 51 can be withdrawn from the insulative ceramic material so leaving the coiled wire 52 embedded within the inner surface of the insulator layer 53 (see Fig. 10c). The orifice left by the withdrawal of the screw 51 can be filled with insulative material 54. In this embodiment, the sacrificial component preferably comprises adjacent portions of respective turns of the coiled wire 52, so leaving wire portions 55 embedded within an insulative member as depicted in Fig. 10e.

Figs 13a-13b depict a still further embodiment of a method for forming a feedthrough according to the present invention. In this embodiment, a series of platinum conductive members are formed on a copper backing (Fig. 13a). A first layer of ceramic can then be moulded thereto (Fig. 13b) before the copper backing is etched away (Fig. 13c). An overmould of ceramic is then provided (see Fig. 13d) to form the completed feedthrough.

As described, the method 10 comprises a step 14 of debinding the green body. In this step, the binder in the green body is extracted from the insulative material, eg ceramic. In one embodiment, this step can comprise a chemical debinding in which the green body is soaked in a suitable solvent. In another embodiment, this step can comprise exposing to a relatively elevated temperature. This temperature is preferably sufficient to boil off the binder from the green body while not causing the green body to undergo sintering. In one embodiment, the temperature is between about 150°C and 200°C.

During the debinding step 14, the insulative material, eg ceramic, preferably shrinks in dimension to form a brown body..

When ready, the brown body can undergo a sintering step (step 15 in method 10). The sintering step 15 preferably comprises exposing the brown body to a suitable elevated temperature. In one embodiment, the sintering step can comprise exposing the brown body to a sintering temperature of about 1700°C. During the sintering step, the ceramic member undergoes further shrinkage and becomes relatively more robust. The shrinkage of the ceramic also serves to form an hermetic seal at the interface between the embedded platinum members and the surrounding sintered insulative member.

Once complete, the insulator member with the platinum members extending therethrough can be brazed into an orifice in the wall of a unit adapted to receive the feedthrough. Electrical connection can then be made to each end of the respective platinum members as required to form respective electrical conductive paths through the insulative body of the feedthrough.

Such a feedthrough can be adapted to be brazed into the wall of an implantable stimulator unit of a cochlear implant hearing prosthesis. In this embodiment, the feedthrough can be adapted to provide electrical conduction between the circuitry within the implantable stimulator unit and the intracochlear or extracochlear electrodes, and/or the implantable receiver coil.

Each feedthrough preferably has sufficient platinum members embedded therein to ensure there are sufficient connectors for each of the electrode

channels of the intracochlear electrode array, one or more extracochlear electrodes, and the inputs from the receiver coil.

The present invention provides a method of forming a feedthrough for an implantable component comprising an insulative member having a plurality of electrically conductive members extending therethrough. The method ensures the electrically conductive members are encased within the insulative member in a way that allows electrical connection through the feedthrough while preventing unwanted transfer of materials between the interior of the component and the surrounding environment.

It will be appreciated by persons skilled in the art that numerous variations and/or modifications may be made to the invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive.

Dated this thirtieth day of September 2002

Cochlear Limited
Patent Attorneys for the Applicant:

F B RICE & CO

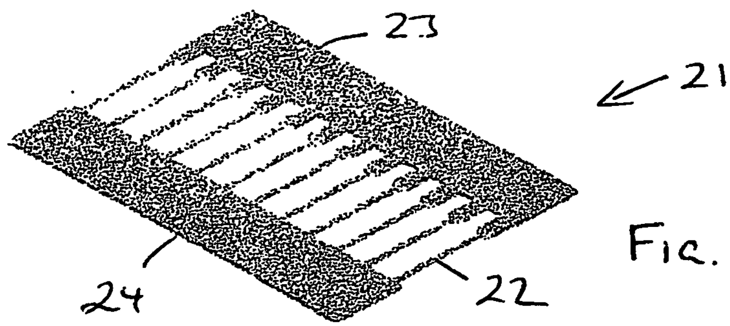

Fig. 1

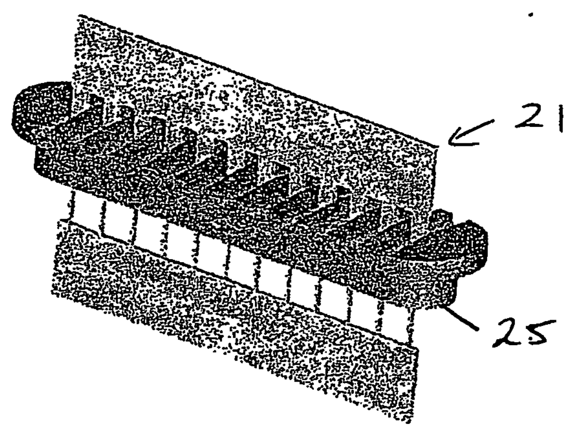

Fig. 2

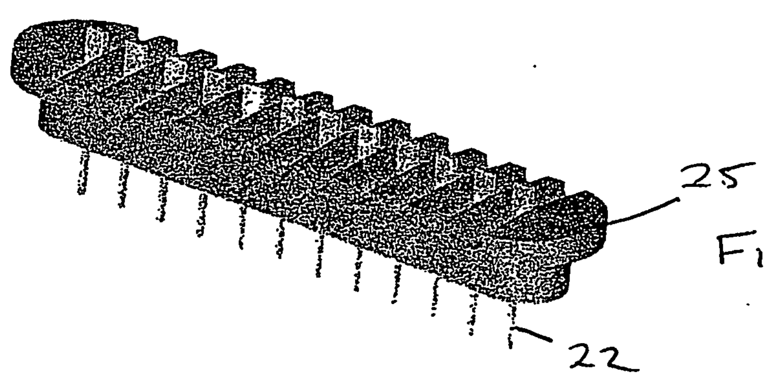

Fig. 3

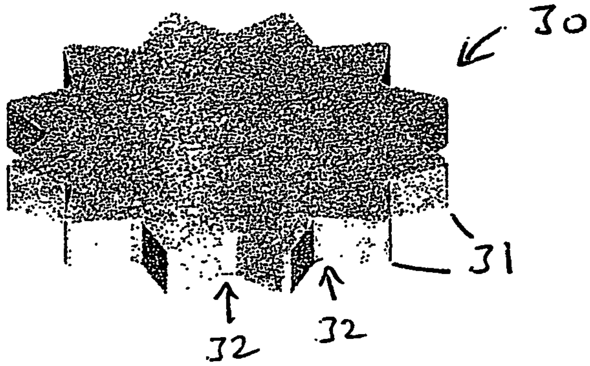

Fig. 4a

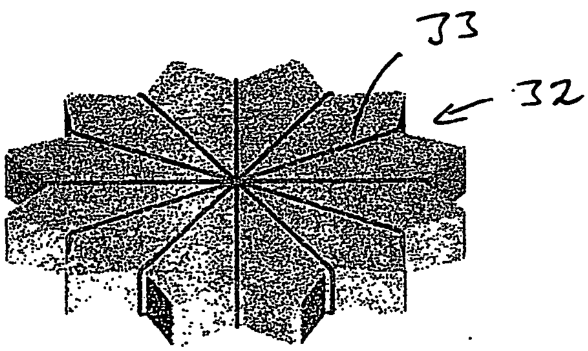

Fig. 4b

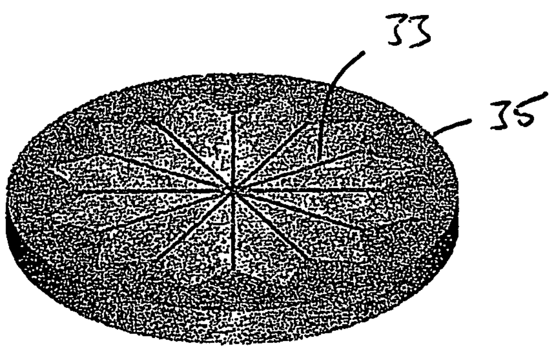

Fig. 5

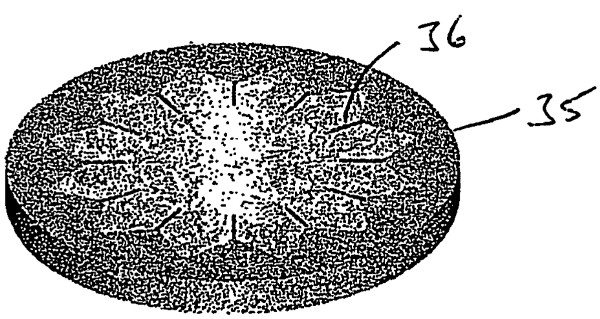

Fig. 6

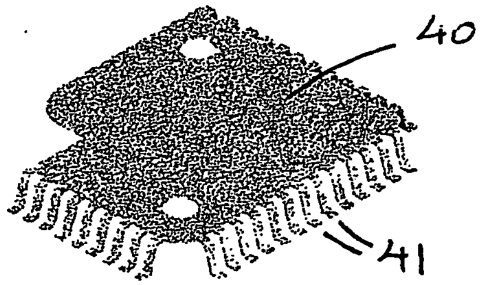

Fig. 7

Platinum plate

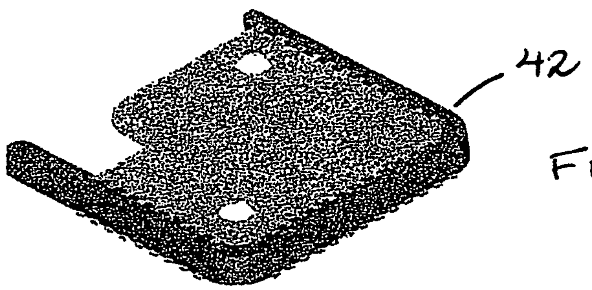

Fig. 8a

Moulded with ceramic

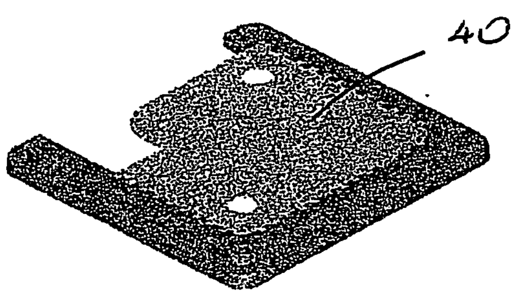

Fig. 8b

Overmould outside with ceramic

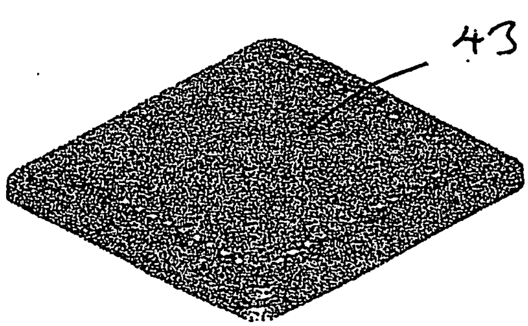

Fig. 9

Overmould inside part and core of platinum is cut out

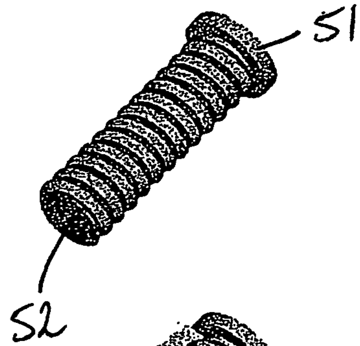

Fig. 10a

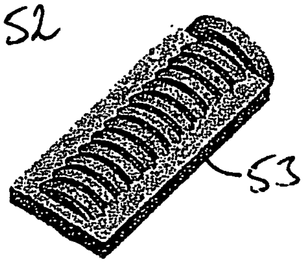

Fig. 10b

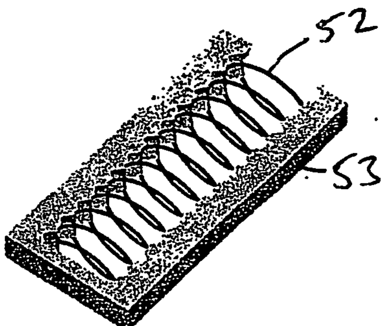

Fig. 10c

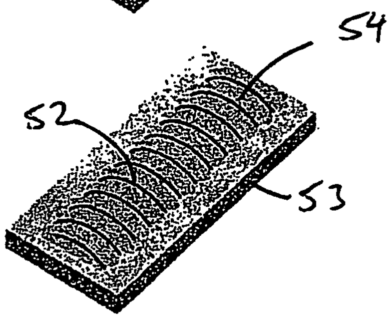

Fig. 10d

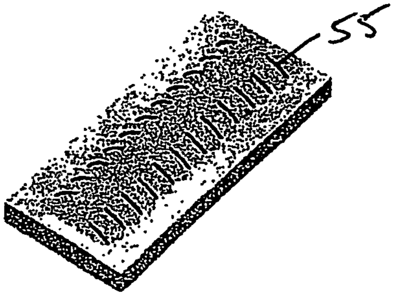

Fig. 10e

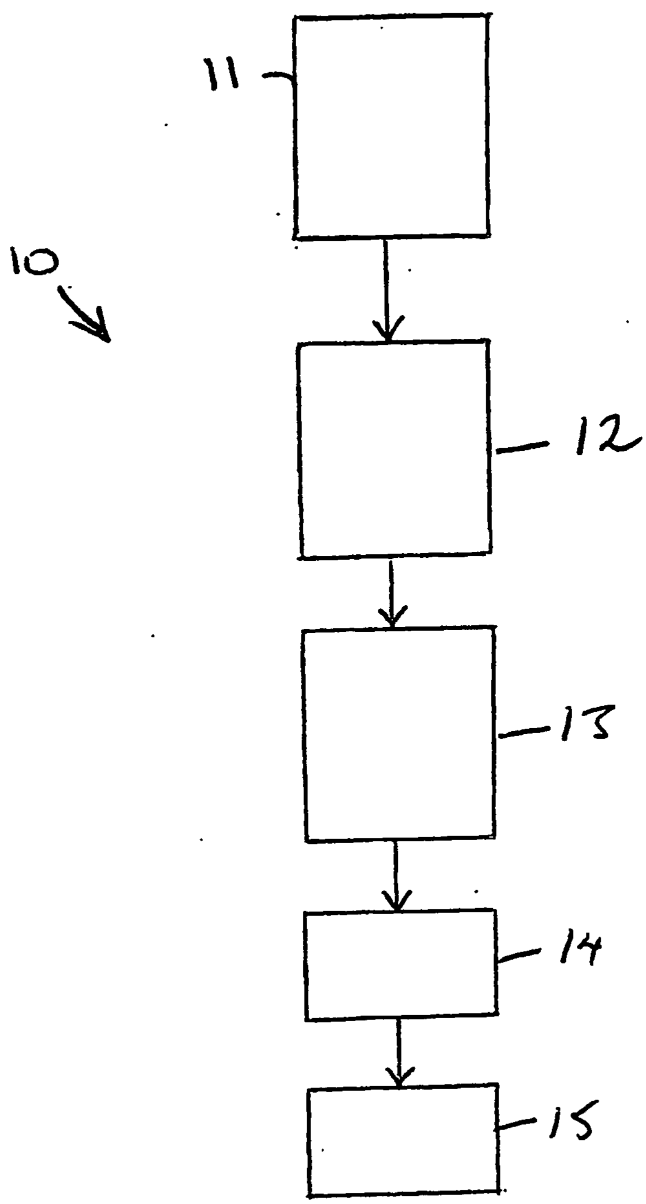

Fig. 11

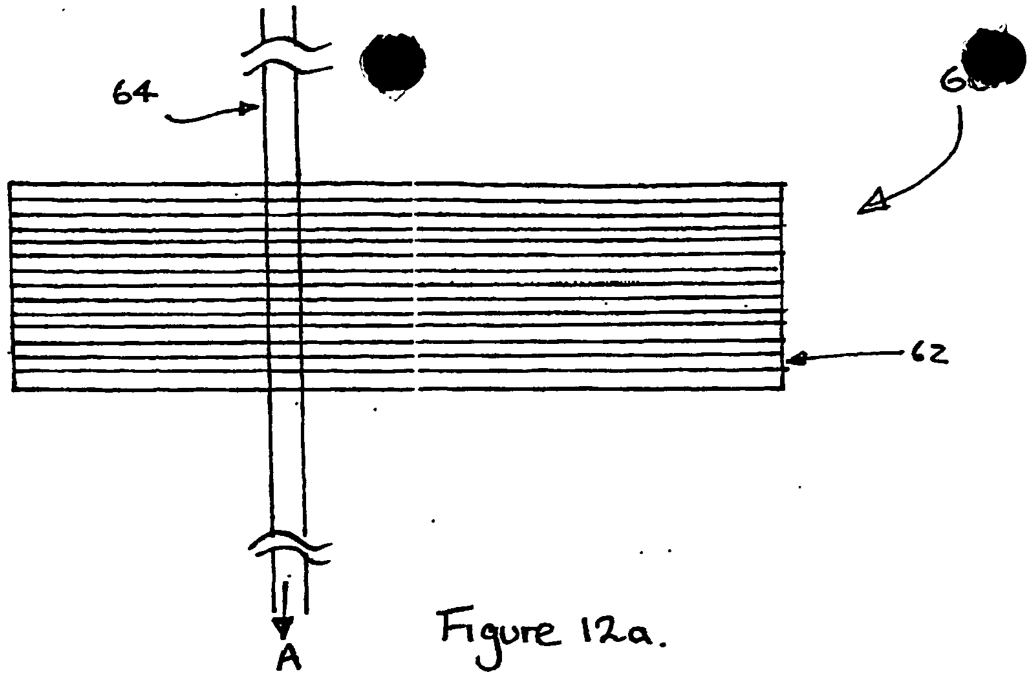

Figure 12a.

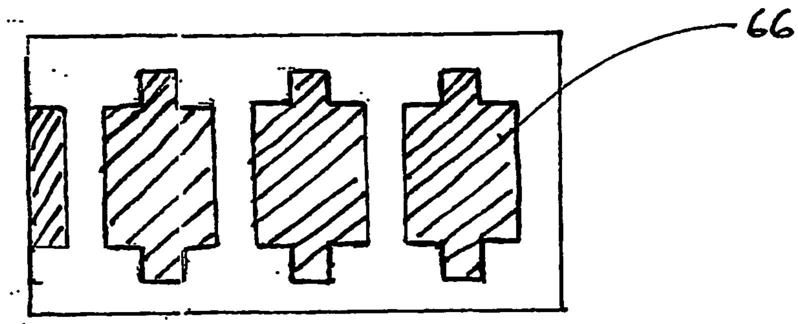

Figure 12b

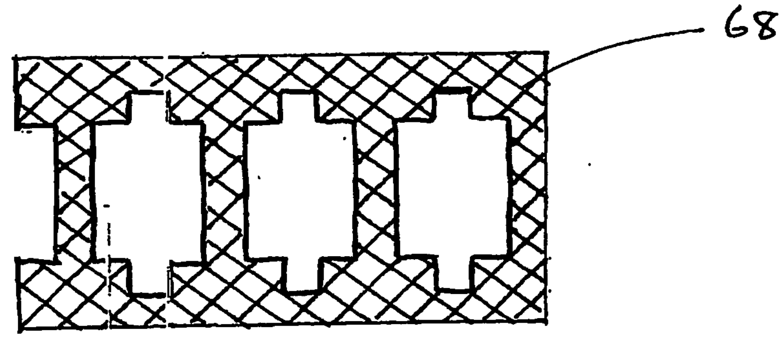

Figure 12c

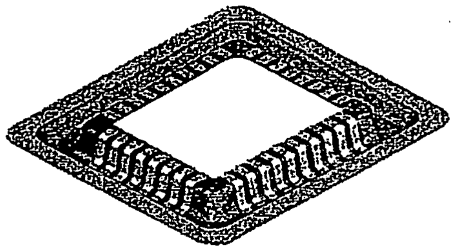

Fig. 13a

Platinum conductive with copper backing

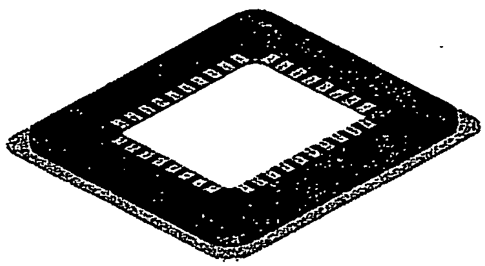

Fig. 13b

Moulded with ceramic

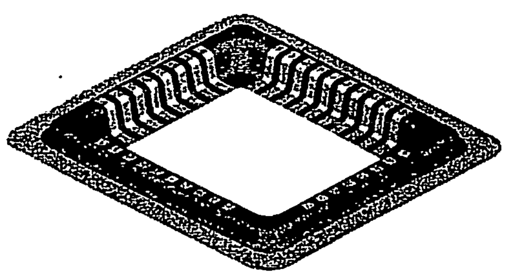

Fig. 13c

Copper backing etched away

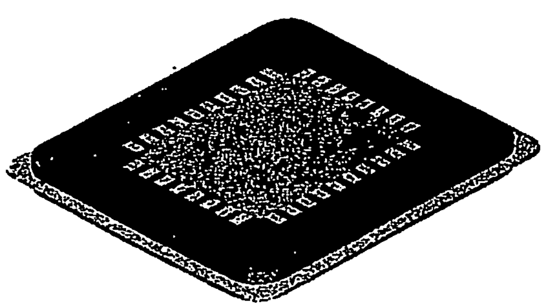

Fig. 13d

Overmould with ceramic